Stratigraphic and Geoacoustic Characterization of the Outer New Jersey Shelf

John A. Goff
University of Texas Institute for Geophysics
4412 Spicewood Springs Rd., Building 600
Austin, TX 78759
Phone: 512-471-0476
Fax: 512-471-0999
E-mail: goff@ig.utexas.edu

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LONG-TERM GOALS

As a participant of the ONR Shallow Water Acoustics experiment to be held on the outer New Jersey shelf during the summer of 2006 (SWA06), the long term goal of this project is to understand the interaction of acoustic energy, at both medium and low frequencies, with the seabed.

OBJECTIVES

The objectives of this work are to (1) incorporate existing geological, geophysical and geoacoustic data into a seabed properties model applicable to the SWA06 experiment region, and (2) geologically interpret additional chirp seismic data to be collected as part of SWA06 (Altan Turgut, PI), and incorporate into existing interpretation based on analysis of the ONR Geoclutter program.

Expected products include:

(1) A structural/stratigraphic model of the subbottom, along primary acoustic propagation pathways planned for the SWA06 experiment and regionally as possible with existing and newly collected chirp seismic data.

(2) A geologic interpretation of the regional stratigraphy based on both new and existing chirp seismic data and available ground truth information. This interpretation will focus on the transition from "outer shelf sediments" to "outer shelf wedge" that spans the intervening region between Areas 1 and 2 (Figure 1).

(3) A geoacoustic rendering of the structural model based on predictive relationships between such properties and the geologic interpretation. Available physical property measurements will be used to constrain such relationships.

APPROACH

Seafloor and subseafloor data readily accessible to the PI (Figure 1) are listed below:

(1) Swath bathymetry and backscatter data were collected in 1996 as part of the STRATAFORM program (Goff et al., 1999) and more recently as an unexpected add-on to the Geoclutter program.

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14. ABSTRACT
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The backscatter data derived from 95 kHz acoustic frequency. Ground truth data demonstrate that, in this region, these data are primarily responsive to the coarse content at the seabed (Goff et al., 2004). Combined analysis with chirp data has also revealed how the seabed morphology can be used to infer the locations of significant seabed erosion (Goff et al.,2005).

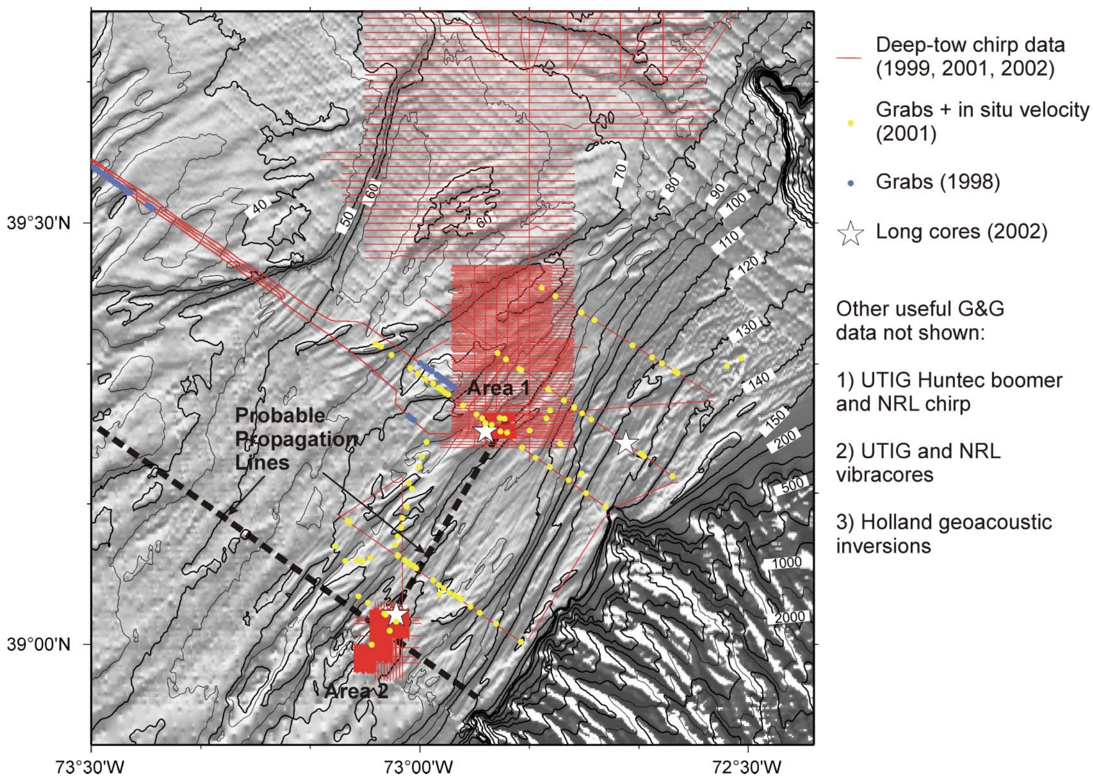

Figure 1. Location of important seabed data and samples, superimposed on bathymetric map of the NJ outer shelf.

(2) Chirp seismic reflection data were collected in 2001 and 2002 for the Geoclutter program (Nordfjord et al., 2004; Gulick et al., 2005). These data have been interpreted structurally (Figure 2). Furthermore, along main dip transects of the 2001 data set, Dr. S. Schock (FAU) has derived seafloor impedance values for 1-4 kHz data (Goff et al., 2004).

(3) Grab samples were collected as part of both the JOI site survey augmentation (Goff et al., 2000) and the geoclutter program (Goff et al., 2004). These samples have been analyzed for grain size distribution.

(4) At the locations of the 2001 grab samples, measurements of in situ velocity at 65 kHz were collected by colleagues at the University of New Hampshire. These values were shown to be correlatable to the mean grain size determined from the grab samples and to the seafloor impedance values derived from the chirp data (Goff et al., 2004).

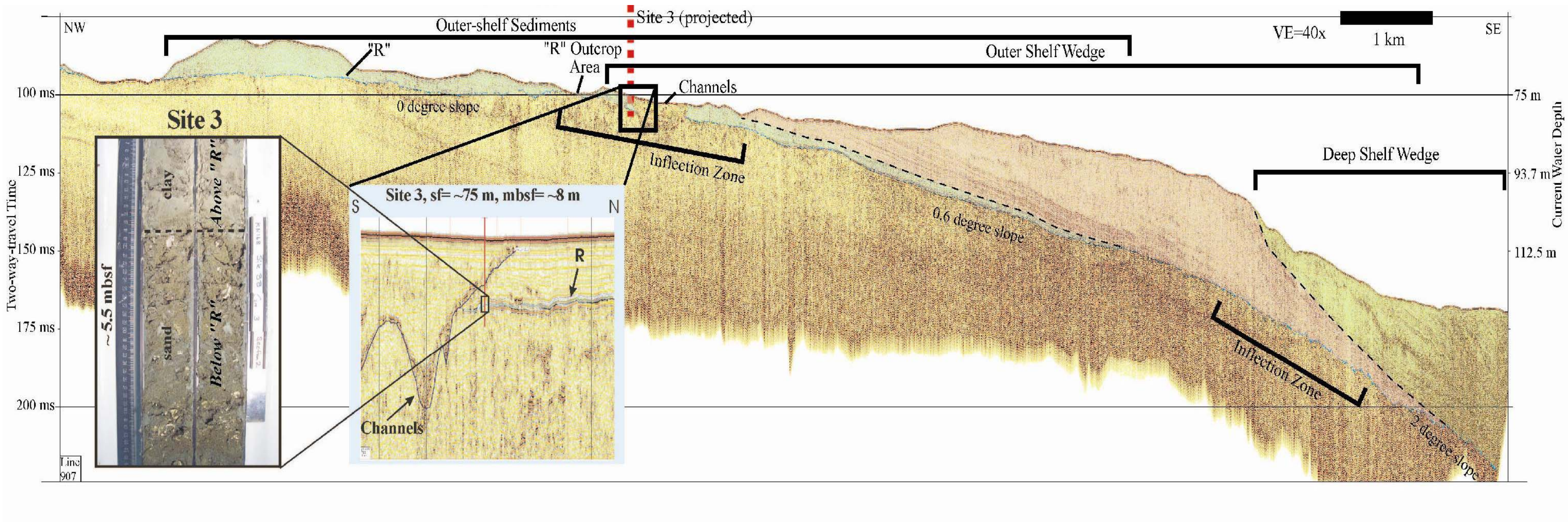

Figure 2. Primary chirp dip line passing through Area 1, with structural interpretation (Gulick et al., 2005). Also shown, in inset, is the location of Core 3 in Area 1, along with photo of the "R" horizon contact.

(5) Three long cores were collected in 2002 using the AHC-800 drilling system. These cores are located within the chirp seismic data (Figure 2). They were analyzed for geologic structure and logged for the geoacoustic properties of velocity, density (Figure 3; Nordfjord et al., 2002).

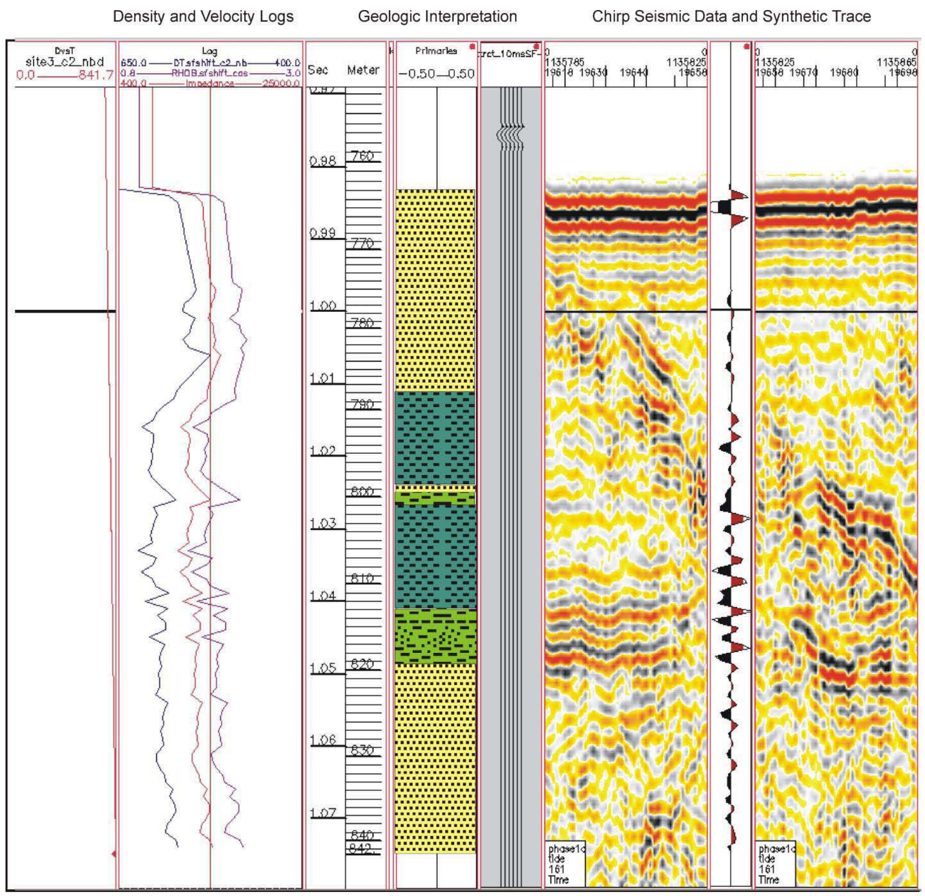

Figure 3. Analysis of Core 3, in Area 1, including density and velocity logs, geologic interpretation (yellow – sand; green = interlaminated mud and sand; aqua = mud), and comparison of synthetic seismic trace, derived from log, with actual chirp data.

Additional important data sets that may be helpful and would likely be accessible to the PI include:

(1) Huntec boomer seismic data and vibracore results from the 1993 UTIG effort sponsored by ONR (e.g., Buck et al., 1999; Duncan et al., 2000). Utilizing these data will require document and record retrieval and reformatting of older digital seismic records.

(2) Chirp seismic data and vibracore results from the 2001 NRL site characterization as part of the SWAT experiment.

(3) Geoacoustic inversion results conducted by Charles Holland (ARL Penn State) at various locations within both Areas 1 and 2 (Kraft et al., in press).
The primary objective of this proposal is to develop a structural model of the seabed and subsurface along the SWA06 propagation pathways, and to populate that model with measured and predicted

geoacoustic properties. The structural model will be based upon the interpreted seismic horizons derived both from existing and to-be-collected chirp or boomer seismic data. Most of the existing data have been interpreted by UTIG colleagues, and exist, along with seismic data, within Geoquest (a commercial seismic interpretation software package) data bases that reside at UTIG. Some in-house processing expertise will be required to merge the available data into a single data structure for a complete synthesis.

The expected SWA06 propagation paths do no always lie along existing chirp track lines. Dr. Altan Turgut of NRL has been contracted to conduct a chirp survey to compliment the available data as needed to cover such gaps in coverage. The PI will collaborate with Dr. Turgut in this survey work. He will also merge that data with the UTIG Geoquest seismic data base for this region (again employing in-house seismic processing expertise), and interpret the seismic horizons seen in the new data in a manner consistent with the previous structural interpretation.

The new chirp data should provide an important geologic product: a structural connection between Areas 1 and 2. Although proximal, the two areas differ in their stratigraphic architecture in a number of important ways. In particular, Area 2 exhibits a thick (nearly 20 m) laminated sequence between the regional “R” reflector and the base of the Holocene sand sheet (or “T” reflector), dipping seaward as part of the “outer shelf wedge” (Figure 2). In Area 1, however, although it is at the same water depth, the sediments between “R” and “T” are much thinner (~5 m at most), flat lying and not well-laminated. Gulick et al. (2005) interpret the latter sediments as an older unit than the outer shelf wedge (“outer shelf sediments”; Figure 2). The transition between these two units represents a critical structural boundary, and a centerpiece of an hypothesis forwarded by Gulick et al. (2005) for the deposition of Pleistocene sediments as a prograding wedge deposited during the lowering of sea level. From the acoustics standpoint, this hypothesis would have important implications for predicting outer shelf sediment properties in many parts of the world (Kraft et al., in press). The additional chirp data to be collected by Dr. Turgut will of necessity focus closely on this structural transition, and thereby provide additional constraints by which to test the Gulick et al. (2005) hypothesis.

Populating any structural model with geoacoustic properties will pose a significant challenge, given the constraints on collecting new ground truth data for the SWA06 project. Physical property measurements, of course, will be used as much as possible. These include: *in situ* measurements at the seabed, core logs, geoacoustic inversion (Holland experiments), and impedance values estimated from chirp seismic data. However, available measurements are limited, particularly along the planned dip and strike lines for the SWA06 experiment (heavy dashed lines in Figure 1), and also particularly at depth below the seafloor. Some form of prediction will be required. The expectation here is that the geologic interpretation of the stratigraphic structure will guide the prediction. Guided by available ground truth and inference from chirp seismic, the PI will, in close collaboration with Dr. Turgut, seek to formulate geoacoustic model for the primary geologic units that takes into account spatial variability (both laterally and with depth) as well as mean properties. This model will then form the basis for filling the structural model with geoacoustic properties.

WORK COMPLETED

Through fortuitous circumstances, last year PI was able to employ extra ship time aboard the *R/V Cape Henlopen*, left over from the Geoclutter program, to conduct bathymetry and backscatter swath mapping over the primary SWA06 dip line (Figure 1) landward of previously available swath coverage (collected during the ONR Strataform program). The additional data will ensure that the acoustic

experiments is conducted in areas that are fully mapped with high resolution bathymetry and backscatter data. The swath system installed on the Cape Henlopen was fairly new at the time, and the operators experience was limited, which resulted in two issues that required post-processing to correct. The bathymetry (Figure 4) were generally of high quality. In the overlapping regions with the previous data set, an offset was discovered that slowly varied with time, reaching a maximum discrepancy of ~2 m. This discrepancy was fixed, and the new data were merged with the previous multibeam data and existing archival data to produce a bathymetric map for the region (Figure 5), which is now available to SWA06 researchers from the SWA web site or from the PI.

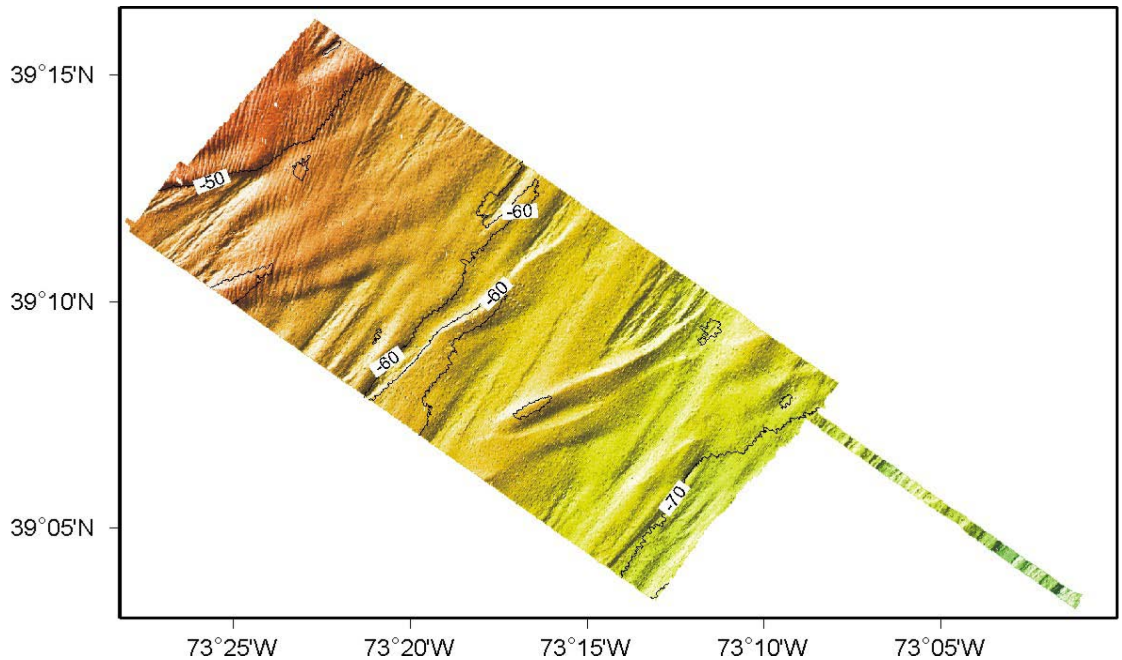

Figure 4. Swath bathymetry collected aboard the R/V Cape Henlopen in 2004. Depths in meters

Unfortunately, an as-yet unknown error in the data file parameters caused the backscatter data collected during the *Cape Henlopen* swath mapping survey to be clipped beyond some specified time limit, which in turn limited the effective backscatter swath width to be well below the bathymetric swath width. The resulting backscatter mosaic (Figure 6) is extremely difficult to interpret, owing to the visual dominance of the track line-oriented gaps in the data. Nevertheless, careful inspection reveals structures and lineaments which correlate with the bathymetric lineaments evident in the multibeam bathymetry data (Figure 5). Employing a directional filter routine developed by Goff et al (2000) and designed to enhance structural lineaments, the resulting image provides a tremendous enhancement (Figure 7), and reveals clearly the remarkable structural complexity of the bottom character of this region. After normalization to the earlier STRATAFORM backscatter image (Goff et al., 1999), the combined backscatter data set is presented in Figure 8. The latter image is also available on the SWA06 web site.

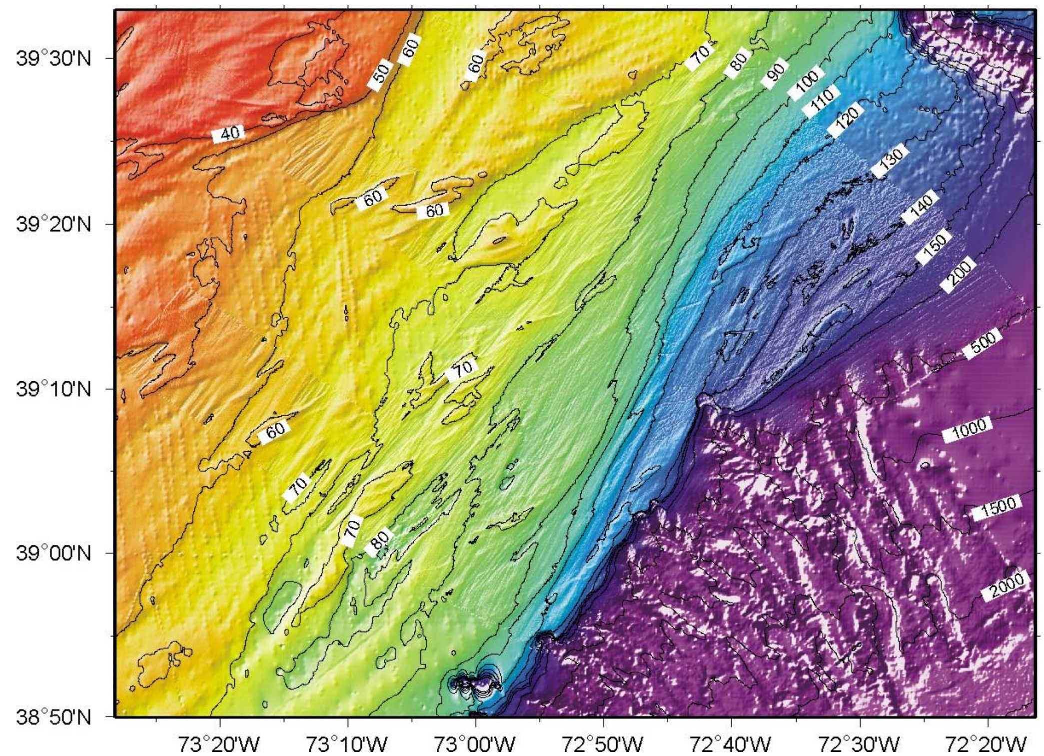

Figure 5. Merged bathymetric data for the SWA06 experiment region. Depths in meters.

RESULTS

This project is in its nascent stage; the work accomplished thus far has been of a technical nature, and has not yet produced scientific results of significance. However, the new bathymetric and backscatter data display highly intriguing geomorphology that will be investigated with additional chirp data and analysis.

IMPACT/APPLICATIONS

The merged bathymetry and backscatter data will be a direct benefit to acoustic and oceanographic modelers working for the SWA06 project.

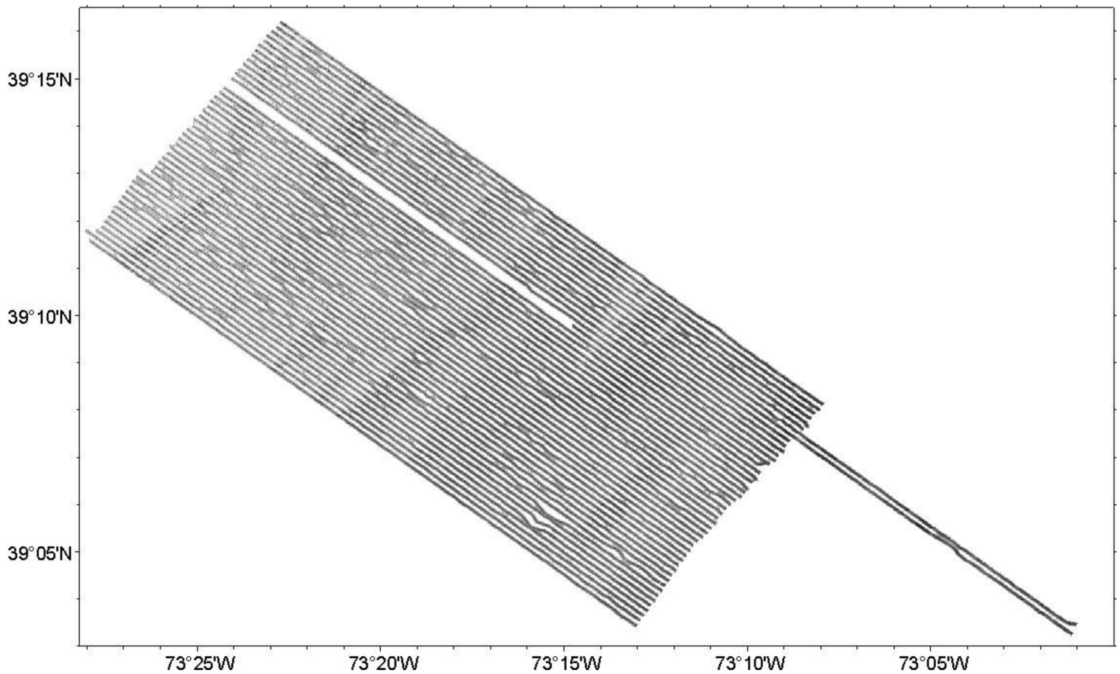

Figure 6. Unprocessed backscatter data for the SWA06 experiment region, displaying significant gaps between swaths. The image is a "negative (darker shades = higher backscatter).

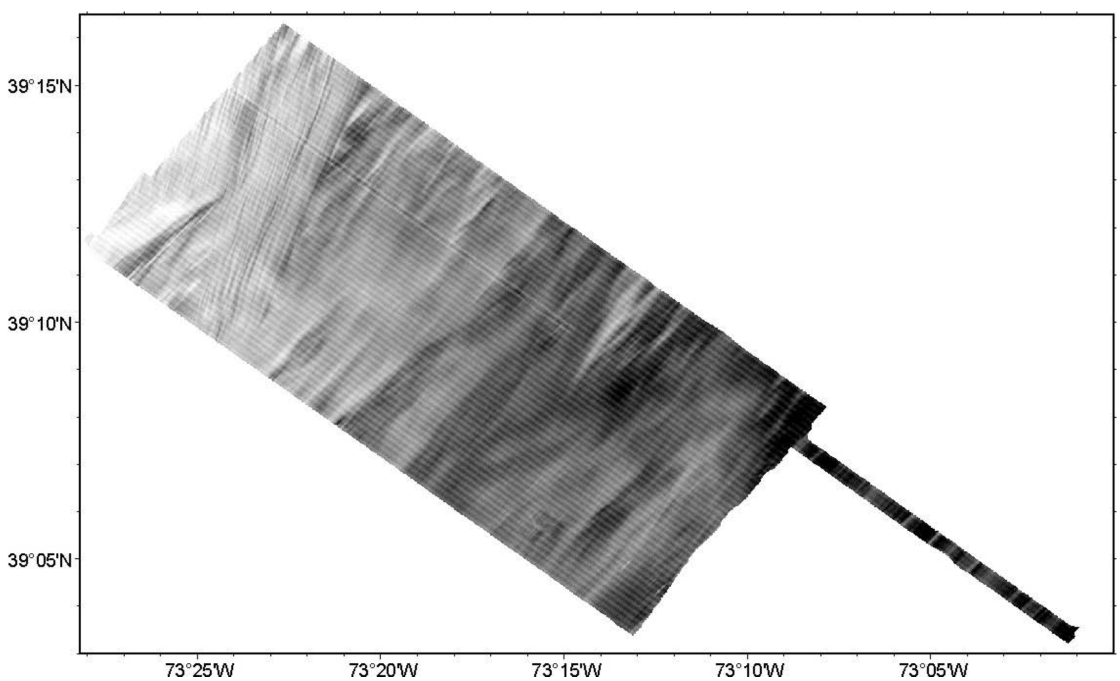

Figure 7. Backscatter data for the SWA06 experiment region after directional filtering to enhance structural trends and bridge gaps. The image is a "negative" (darker shades = higher backscatte)r.

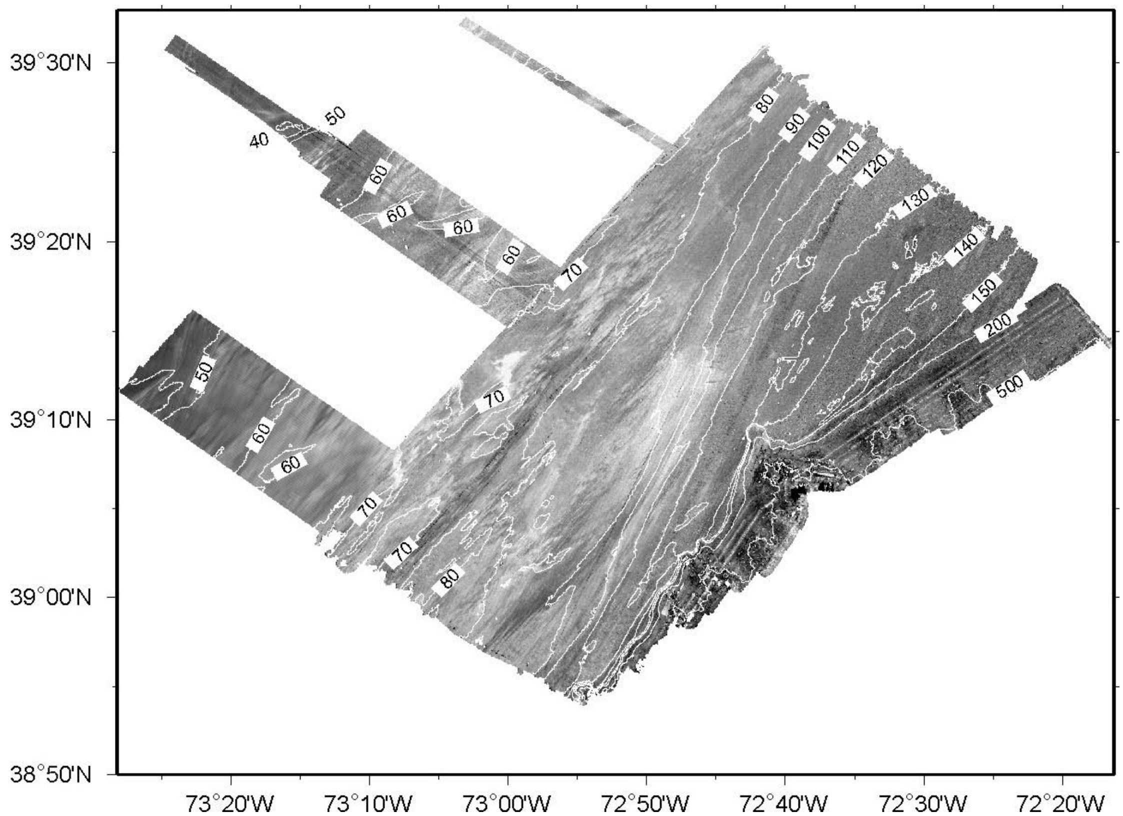

Figure 8. Merged backscatter data(95 and 200 kHz) for the SWA06 experiment region. The image is "positive" (lighter shades = higher backscatter). Depths in meters.

RELATED PROJECTS

The ONR Geoclutter, STRATAFORM and Uncertainty in the Natural Environment projects have provide significant data and modeling inputs for this project.

REFERENCES

Buck, K. F., H. C. Olson, J. A. Austin Jr., Paleoenvironmental evidence for Latest Pleistocene sea level fluctuations on the New Jersey outer continental shelf: combining high-resolution sequence stratigraphy and foraminiferal analysis, *Mar. Geol.*, *154*, 287-304, 1999.

Duncan, C. S., Late Quaternary Stratigraphy and Seafloor Morphology of the New Jersey Continental Shelf, PhD. Thesis, University of Texas, 222 pp, 2001.

Duncan, C. S., J. A. Goff, J. A. Austin, and C. S. Fulthorpe, Tracking the last sea level cycle: seafloor morphology and shallow stratigraphy of the latest Quaternary New Jersey middle continental shelf, *Mar. Geol*., *170*, 395-421, 2000.

Goff, J. A., D. J. P. Swift, C. S. Duncan, L. A. Mayer, and J. Hughes-Clarke, High resolution swath sonar investigation of sand ridge, dune and ribbon morphology in the offshore environment of the New Jersey Margin, *Mar. Geol.*, *161*, 309-339, 1999.

Goff, J. A., H. C. Olson and C. S. Duncan, Correlation of sidescan backscatter intensity with grain-size distribution of shelf sediments, New Jersey margin, *Geo-Marine Letters*, *20*, 43-49, 2000.

Goff, J. A., B. J. Kraft, L. A. Mayer, S. G. Schock, C. K. Sommerfield, H. C. Olson, S. P. S. Gulick, and S. Nordfjord, Seabed characterization on the New Jersey middle and outer shelf: Correlability and spatial variability of seafloor sediment properties, *Mar. Geol.*, *209*, 147-172, 2004.

Goff, J. A., J A. Austin, Jr., S. Gulick, S. Nordfjord, B. Christensen, C. Sommerfield, and H. Olson, C. Alexander, Recent and modern marine erosion on the New Jersey outer shelf , *Mar. Geol., 216*, 275-296, 2005.

Gulick, S. P. S., J. A. Goff, J. A. Austin, Jr., C. R. Alexander, Jr., S. Nordfjord, and Craig S. Fulthorpe, Basal inflection-controlled shelf-edge wedges off New Jersey track sea-level fall, *Geology*, *33*, 429-432, 2005.

Kraft, B. J., I. Overeem, C. W. Holland, L. F. Pratson, J. P. M. Syvitski, and L. A. Mayer, Stratigraphic model predictions of geoacoustic properties, *IEEE J. Ocean Eng*., in press.

Nordfjord, S., S. P. Gulick, J. A. Austin Jr., J. A. Goff, C. S. Fulthorpe, Late Quaternary incisions and related shallow subsurface stratigraphy on the New Jersey mid-outer shelf: preliminary results from ultra-high resolution chirp sonar images - part I, *Eos Trans. AGU*, *83*, Fall Meet. Suppl., Abstract OS71C-0299, 2002

Nordfjord, S., J. A. Goff, J. A. Austin, Jr., and C. K. Sommerfield, Seismic geomorphology of buried channel systems on the New Jersey outer shelf: Assessing past environmental conditions, *Mar. Geol*., 214, 339-364, 2005.